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Floating Row Cover to Produce Early Ripening of Strawberry

BY MARTIN P.N. GENT

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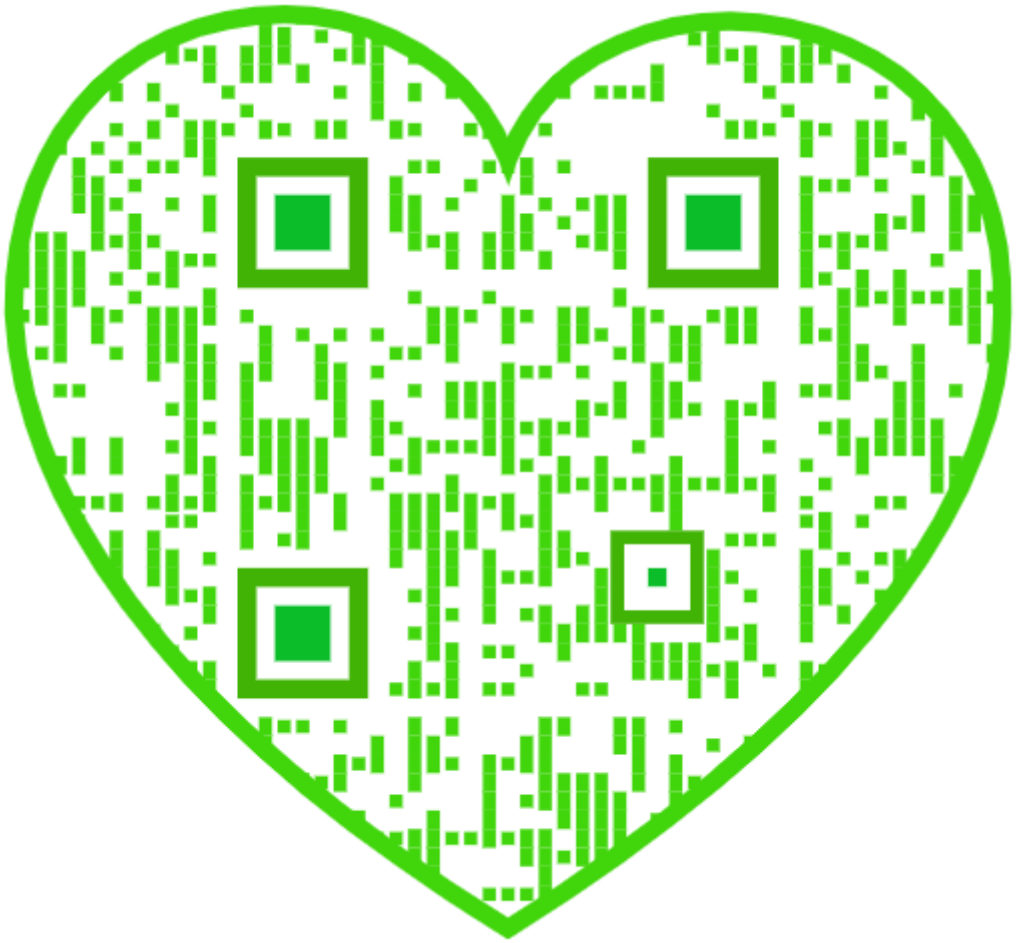

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Floating Row Cover to Produce Early Ripening of Strawberry

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About 500 acres of strawberry (*Fragaria x ananassa* Duch.) are grown in Connecticut. These perennial plants are overwintered under straw mulch applied in November to moderate temperature fluctuations and prevent death of the crown. In early spring, this mulch is raked away from the plants and into the aisles where it serves as a ground cover to inhibit weed growth and keep the berries clean. Straw or salt marsh hay to mulch strawberry fields is scarce, and producers often grow their own, which requires an area similar in size to the area of strawberries. The alternative of buying straw on the open market has become expensive and quality is sometimes poor.

Most Connecticut strawberries are marketed as Pick-Your-Own. The consumer picks the strawberries at their peak quality, and the farmer avoids the expense of labor for picking. Pick-Your-Own is ideally suited for Connecticut strawberry producers because of the high density of consumers nearby. The principal limitation to marketing strawberries through Pick-Your-Own is the short production season. Nearly all cultivars in commercial production are June bearing, that is, they produce ripe fruit in June. A particular cultivar at a particular location will produce for about 3 weeks. If the weather is rainy or unusually hot during fruit production, the opportunity to Pick-Your-Own is reduced. Consequently, strawberry producers often have surplus fruit near the end of the picking season that must either be picked by hired hands or be offered at a discount.

Synthetic mulches and row covers are alternatives to straw and their use in strawberry cultivation may provide a way to extend the season of fruit production. Trials in Wisconsin using clear polyethylene row cover as an overwinter mulch caused fruit to ripen 10 to 13 days earlier than straw covered plants (Scheel, 1982). Spun bonded polypropylene and polyester films are porous light-weight materials. When used as row cover to protect strawberry over winter in New Hampshire, they increased yields over straw mulched controls (Pollard and Cundari, 1988). Plants under row cover grew faster in early spring and flowered 2 to 3 weeks earlier (Pollard, personal communication 1988). In Connecticut, Mr. Roger Eddy of Newington noted the earlier flowering of plants under row cover, but he did not get earlier production. It is not clear why the more rapid development of strawberry plants grown under floating row cover in early spring does not translate to early yield.

Black plastic mulch used as a ground cover can accelerate growth of strawberry and other crops, and prevent weeds (Hill et al 1982). Black polyethylene mulch used in combination with a winter cover of spun bonded polypropylene may eliminate entirely the need for straw in strawberry production. In Connecticut, higher yields of strawberry resulted in the year following planting into black polyethylene as a ground mulch compared to bare ground (Waggoner et al 1960). The acceleration of development by plastic mulch and fabric row cover may be additive and may result in earlier ripening of strawberry (Lutz 1984).

The early production of strawberry using spun bonded fabric row cover as a winter mulch is the subject of this study. These materials are relatively expensive, approximately $700/acre. With care, they can be reused for several winters. If they extend

the picking season by causing earlier fruit ripening, they will benefit the producer. There will be a longer period to attract Pick-Your-Own customers, and the berries will be available at the time of highest demand and price.

METHODS

Plant material and cultivation

Bare rooted strawberry plants were obtained from Nourse Farms, South Deerfield, MA. Seven of the eight cultivars were June bearing. In order of earliness they were Earlidawn, Earliglow, Midway, Redchief, Guardian, Scott, and Jerseybelle. The everbearing cultivar, Tribute, was similar to Midway in earliness of the June production. See Table 1 for a summary of the characteristics of these cultivars.

In 1987 and 1988, field trials were conducted at Lockwood Farm in Hamden, CT. Plants were planted through black polyethylene ground mulch and overwintered under a row cover of spun bonded polypropylene. Eight strawberry cultivars were evaluated using this cultural practice. The timing of production and the quantity and quality of fruit were measured.

The yield trial was conducted on a level field on the crest of a knoll. The soil was Cheshire fine sandy loam with a pH of 6 and medium to high level of all nutrients except N. In April 1986 the cover crop of rye was killed with herbicide and the soil was plowed and leveled. Black polyethylene mulch was laid east to west in 4-foot strips with 2-foot aisles between them. A 6-inch border of mulch was buried in the soil on either side and the mulch was also held in place with stones. On May 7 and 8, bare-root strawberry plants were set through holes punched in the mulch in double rows with a 2-foot distance between plants. Plants were deblossomed through May and June. On July 11 two runners per plant were selected and established

TABLE 1--CHARACTERISTICS OF STRAWBERRY CULTIVARS

Cultivar	Parents	Earliness	Fruit Character		Disease Resistance	
			Size	Taste/ Firmness	Verticillium	Red Stele
June Bearing						
Earlidawn	Midland x TN Shipper	Early	Medium Small	Tart	-	-
Earliglow	MD US 3861	Early	Medium Large	Sweet Firm	+/-	+
Guardian	NC 1768 x Surecrop	Mid-Late	Large	Sweet	+	+
Jerseybelle		Late	Large	Sweet Soft	-	-
Midway	Dixieland x Temple	Mid-Early	Medium	Firm	-	+
Redchief	NC 768 x Surecrop	Mid	Medium Large		+/-	+
Scott	Sunrise x Tioga	Mid	Large	Firm	+/-	+
Everbearing						
Tribute	EB 18 x MD US 4258	Mid-Early	Small	Tart Firm	+	+

as new plants by punching a hole in the plastic mulch and pinning the daughter plant in the hole with a hair pin. The plot was maintained at a plant density of 1.5 plants per foot of row or 22000 plants per acre throughout the trial. All new runners were cut off the plants and removed from the field on August 15, 1986 and July 24, 1987.

Plants were renovated after fruit production in the second year: plants were mowed at a height of 3 inches and all leaves were removed. In late July in 1986 and 1987, 10:10:10 fertilizer was broadcast at a rate of 600 lbs per acre and incorporated into the aisles with a rototiller. The plot was thoroughly watered after application of fertilizer. Weeds within the mulched areas were controlled by hand as needed. Aisles were sprayed with Paraquat twice each year. The plot was sprayed with Ronilan and Captan on May 4 and 20 to prevent fungus diseases of the fruit.

Treatments

Spun bonded polypropylene (Kimberly Farms floating row cover, Kimberly Clark Co., Roswell, GA) was applied over the plants in the fall of 1986 and 1987. Five-foot wide strips of material covering a double row of plants, was fastened by burying 3 inches of each edge in the soil.

The field was divided into four plots arranged north and south that were covered on different dates. Plots were covered on September 22, September 29, October 10, or October 17 in 1986. Within each plot, one section was left uncovered; it was mulched with straw on November 24, 1986. In 1987, plots were covered on September 3, October 6, October 29 or November 25. Again, an uncovered section in each plot was covered with straw on November 25, 1987.

The straw was removed on March 27, 1987 and March, 25 1988. The field was subdivided into five plots arranged east to west from which the row cover was removed on different dates. In 1987, the row cover was removed on March 27, April 20, May 1, or May 14. In 1988, the row cover was removed on March 25, April 14, May 4, or May 16.

Measurements

In 1987, the number of open flowers and the number of fruit were counted on five plants per plot when row covers were removed. In both years, fruit was harvested at 5-day intervals. Fruit was picked when completely red, but not necessarily fully ripe. A 6.5-foot length of row was harvested repeatedly from each plot. The total weight and number of fruit was recorded and a representative sub-sample of 25 fruit was graded into marketable and unmarketable fruit and each fraction was weighed. Marketable fruit were those firm, symmetrical shaped berries weighing more than 6 grams (less than 75 berries per pint). Accumulated yields and numbers of ripe fruit were determined for each plot. The mid-harvest date, the time that half the total yield for the season was picked, was obtained by linear interpolation between two actual harvest dates.

Weights per berry for each picking were calculated from the weight of fruit picked divided by the number of berries. The cumulative weight per berry was obtained by dividing the cumulative yield by the cumulative number of fruit. Yield, weight per berry, percentage of marketable fruit, and mid-harvest date were analyzed by two-way analysis of variance. The effects of either cover date or removal date were determined separately for each cultivar, with data averaged over the other factor. There was no significant effect of date of application of row cover. The four plots differing in row cover application date were used as replications in determining the effect of date of removal of row cover. Least significant differences were determined according to Duncan's multiple range test at the 5% confidence level.

RESULTS

Survival over the Winter

Strawberry plant survival over winter was equally good under row cover or straw, about 95% in both 1987 and 1988. Two cultivars, Midway and Tribute, survived less well than the others. This did not appear to be related

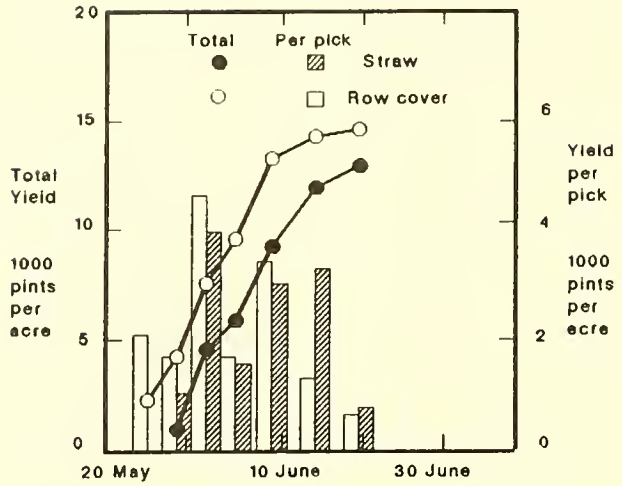

FIGURE 1--YIELD PER PICK (BARS) AND ACCUMULATED YIELD (CURVES) IN 1987 OF EARLIGLOW STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

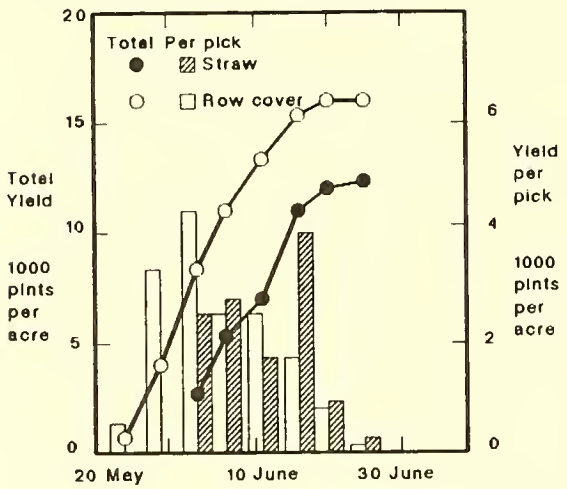

FIGURE 2--YIELD PER PICK (BARS) AND ACCUMULATED YIELD (CURVES) IN 1988 OF EARLIGLOW STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

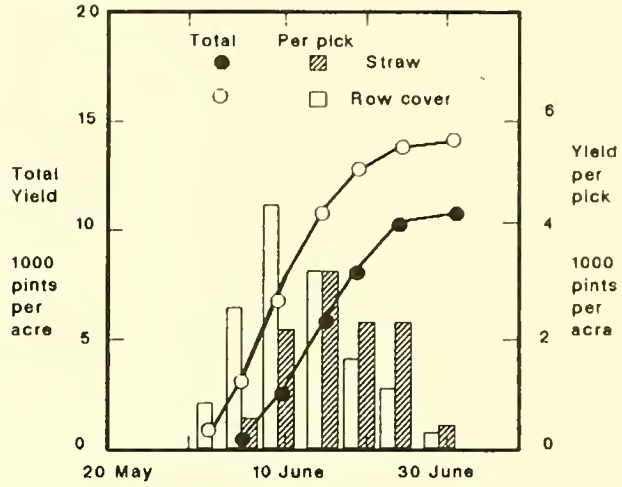

FIGURE 3--YIELD PER PICK (BARS) AND ACCUMULATED YIELD (CURVES) IN 1987 OF JERSEYBELLE STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

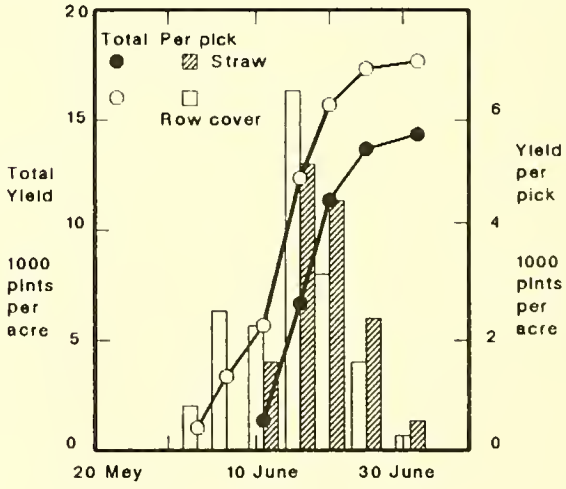

FIGURE 4--YIELD PER PICK (BARS) AND ACCUMULATED YIELD (CURVES) IN 1988 OF JERSEYBELLE STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

TABLE 2--FIRST HARVEST AND MID-HARVEST DATES IN 1987 OF STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

	First harvest date		Mid-harvest date	
Cultivar	Straw	Row Cover	Straw	Row Cover
Earlidawn	31 May	23 May	7 Jun	1 Jun
Earliglow	29 May	23 May	4 Jun	30 May
Guardian	2 Jun	27 May	8 Jun	5 Jun
Jerseybelle	5 Jun	1 Jun	13 Jun	8 Jun
Midway	31 May	25 May	7 Jun	1 Jun
Redchief	1 Jun	27 May	8 Jun	4 Jun
Scott	30 May	27 May	9 Jun	5 Jun
Tribute	2 Jun	27 May	7 Jun	3 Jun
L.S.D. 5%	2.1		2.4	
All	1 Jun	26 May	9 Jun	4 Jun
L.S.D. 5%	0.9		0.9	

TABLE 3--FIRST HARVEST AND MID-HARVEST DATES IN 1988 OF STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

	First harvest date		Mid-harvest date	
Cultivar	Straw	Row Cover	Straw	Row Cover
Earlidawn	5 Jun	28 May	13 Jun	4 Jun
Earliglow	2 Jun	26 May	11 Jun	6 Jun
Guardian	7 Jun	1 Jun	15 Jun	9 Jun
Jerseybelle	13 Jun	6 Jun	20 Jun	15 Jun
Midway	4 Jun	28 May	12 Jun	4 Jun
Redchief	6 Jun	31 May	14 Jun	8 Jun
Scott	8 Jun	3 Jun	17 Jun	12 Jun
Tribute	2 Jun	28 May	12 Jun	7 Jun
L.S.D. 5%	2.1		2.4	
All	6 Jun	30 May	14 Jun	8 Jun
L.S.D. 5%	0.8		0.9	

to the use of row cover versus straw as a winter mulch, but rather to poor growth with the black plastic mulch. In addition, the fungus, *Armillaria*, was tentatively identified as the cause of plant death in a small area of the field. Results from the affected area were not used in later analysis.

Flowering and Fruit Set

The most obvious effect of row cover was acceleration of vegetative growth and flowering. On April 20, 1987, Earliglow plants with row cover recently removed had about one open flower per plant while plants overwintered under straw had none. By May 1 most of the plot was in full bloom. Earliglow plants with row cover removed on May 1 had equal numbers of flowers and immature fruit while plants overwintered under straw had fewer flowers and less than one fruit per plant. The last row cover was removed on May 14, past the peak of flowering for Earliglow. Plants with row cover removed on May 14 had four times more fruit than plants overwintered under straw. Fruit set was not prevented by row cover. A majority of the fruit on plants covered until May 14 was set while the plants were covered. Thus row cover accelerated flower development and fruit set compared to plants overwintered under straw. This acceleration continued until the row cover was removed.

At Hamden, May 15 is considered to be the last frost date. Clearly, overwintering under row cover increased the danger of frost damage to flowers. On nights when frost was predicted the plot was sprinkled from 10 p.m. to 6 a.m. to prevent damage. In 1988, an unexpected frost occurred when the plot was not sprinkled. Observation of flowers after this event suggested that a frost to 30 F did not damage flowers under row cover, whereas exposed flowers were damaged.

Fruit Production

The first ripe fruit were noted on May 21, 1987 and May 24, 1988. In each year, fruit ripened first on plants that remained under row cover longest. The response of plants overwintered under straw that was removed in late March was compared to that of plants overwintered under row cover and uncovered the first week in May. Removal in early May was optimum in that it gave the greatest advance in fruit ripening without sacrificing quality. There was some effect of row cover removal date on earliness and yield, which will be described later. The time of application of row cover had no effect on either earliness or yield.

The timing of yield of Earliglow in 1987 and 1988 is illustrated in Figures 1 and 2, respectively. The amount of fruit picked per week is shown by the bars. Essentially, the production of ripe fruit occurred 1 week earlier for plants grown under row cover until full bloom compared to plants grown under straw. The accumulated weight of ripe strawberries from the start of picking is shown by the curves. The curves illustrate that growth under row cover both decreased the time to fruit ripening by about 7 days and increased the total yield by 10 to 20%. Similar results were obtained in both years.

The same response to row cover was seen for later cultivars, whose flower development and fruit set occurred later in spring. The yield of ripe fruit for Jerseybelle in 1987 and 1988 is illustrated in Figures 3 and 4, respectively. For this cultivar, the removal of row cover corresponded to the early bloom stage in plant development, rather than full bloom. Nevertheless, the response to row cover was similar to that of Earliglow, namely, the fruit ripened about one week earlier and yield was increased 20% compared to that of plants overwintered under straw.

Fruit ripening of both early and late cultivars was advanced by row cover and the genetic and cultural effects on ripening were additive. The earliness of yield was most accurately expressed as the mid-harvest date, that date on which the accumulated yield (shown by the curves in Figures 1 through 4) equaled half the final yield. This date generally corresponded to the peak of fruit production. The first harvest and mid-harvest dates, averaged over the four replicate plots of each cultivar, are reported in Tables 2 and 3, for 1987 and 1988, respectively.

Earlidawn, Earliglow and Midway were the earliest cultivars. The mid-harvest date of Earlidawn and Midway was most sensitive to row cover. Compared to plants overwintered under straw, row cover advanced the mid-harvest date of Earlidawn 5 and 10 days, in 1987 and 1988, respectively. Midway was advanced 8 and 9 days. The time of ripening of everbearing Tribute was least affected by row cover. The mid-harvest date of Tribute was advanced 4 and 5 days, in 1987 and 1988, respectively. Averaged over all cultivars, ripening advanced 4 and 6 days in 1987 and 1988.

In these comparisons, the control consisted of plants overwintered under straw that was removed from the field in late March. Black plastic mulch covered the ground during flowering and fruit production. Normal cultural practice uses straw as a ground cover. To give an idea of the effects of these two different ground covers, black plastic and straw, the timing of yield in 1987 was analyzed for a field of the cultivar, Honeoye, in which the principal variables were whether beds were raised or flat and the choice of ground mulch. In this experiment a black plastic mulch advanced the mid-harvest date by 1 and 3 days in flat and raised beds respectively. (I thank Dr. Wade Elmer of the Plant Pathology and Ecology Department for providing these data.) Thus, the mulch had much less effect than row cover on earliness.

In general, good yields were obtained for strawberries grown under row cover and on black plastic mulch. The total yields for each cultivar are listed in Tables 4 and 5, for 1987 and 1988, respectively. The average yields over all cultivars were 13 and 15 thousand pints per acre in 1987 and 1988, respectively. The yield of most cultivars increased in the second year. Yields of Midway and Tribute decreased due to poor plant vigor. The yield of most cultivars was greater when grown under row cover until early May, compared to those overwintered under straw. Redchief and Guardian were exceptions, both also yielded less under row cover in 1988. Row cover increased yield of the late cultivar Jerseybelle more than 3000 pints per acre in both years. Earliglow and Scott also showed large yield increases in the second year.

Row cover had a less beneficial effect on yield of marketable fruit. Although there was an increase in marketable yield of plants grown under row cover compared to those grown under straw, the increase was not significant in either year, see Tables 6 and 7. The increase in total yield was offset by a decrease in fruit quality for plants grown under row cover.

The decrease in quality was related to a decrease in size of the fruit. Figures 5 and 6 illustrate the trend with time of fruit size of Earliglow, in 1987 and 1988, respectively. In both years the average size of fruit picked each week, illustrated by the bars, was smaller for plants grown under row cover removed in early May than for those overwintered under straw removed in late March. The effect on fruit size was most noticeable for the first fruit picked. The earliest fruit tended to be the largest, and fruit size decreased dramatically toward the end of picking. The curves illustrate the cumulative fruit size, that is the accumulated yield divided by the accumulated number of berries since the start of picking. At the mid-harvest date, berries from plants grown under straw were 15 to 20% larger than those from plants under row cover. Row cover affected fruit size of Jerseybelle less than Earliglow. Jerseybelle overwintered under straw produced bigger berries only at the mid—harvest date in 1988, as illustrated in Figures 7 and 8 for 1987 and 1988, respectively.

The fruit size of different cultivars was compared. To account for the change in size with time of picking, the cumulative fruit size at the mid-harvest date was determined. This was translated to berries per pound in Tables 8 and 9. Averaged over all cultivars, the berry size and the effect of row cover on berry size was similar in each year. In each year Jerseybelle produced the largest berries and Tribute produced the smallest. All the cultivars except Jerseybelle had smaller fruit when grown under row cover compared to straw.

Because of the decrease in berry size,

TABLE 4--TOTAL YIELD IN 1987 OF STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
	1000 pints/acre	
Earlidawn	10.3	12.6
Earliglow	13.1	14.9
Guardian	8.7	13.3
Jerseybelle	10.7	14.1
Midway	11.0	15.7
Redchief	14.6	16.2
Scott	15.1	15.5
Tribute	9.5	10.6
L.S.D. 5%	5.3	
All	11.7	13.9
L.S.D. 5%	1.6	

TABLE 5--TOTAL YIELD IN 1988 OF STRAWBERY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
	1000 pints/acre	
Earlidawn	13.4	14.7
Earliglow	12.3	15.9
Guardian	17.1	15.6
Jerseybelle	14.4	17.9
Midway	11.2	12.6
Redchief	18.7	14.7
Scott	18.4	22.8
Tribute	7.0	9.0
L.S.D. 5%	4.6	
All	14.8	15.5
L.S.D. 5%	1.8	

TABLE 6--YIELD OF MARKETABLE FRUIT IN 1987 OF STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
	1000 pints/acre	
Earlidawn	9.2	10.6
Earliglow	12.0	12.4
Guardian	7.8	10.9
Jerseybelle	9.0	11.7
Midway	9.1	12.7
Redchief	12.6	13.6
Scott	12.7	12.9
Tribute	6.3	7.6
L.S.D. 5%	5.0	
All	10.0	11.4
L.S.D. 5%	1.5	

TABLE 7--YIELD OF MARKETABLE FRUIT IN 1988 OF STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
	1000 pints/acre	
Earlidawn	9.9	11.7
Earliglow	11.4	14.3
Guardian	15.5	13.7
Jerseybelle	13.3	16.7
Midway	9.8	10.3
Redchief	16.1	12.3
Scott	16.0	19.6
Tribute	5.8	6.9
L.S.D. 5%	4.3	
All	13.0	13.3
L.S.D. 5%	1.7	

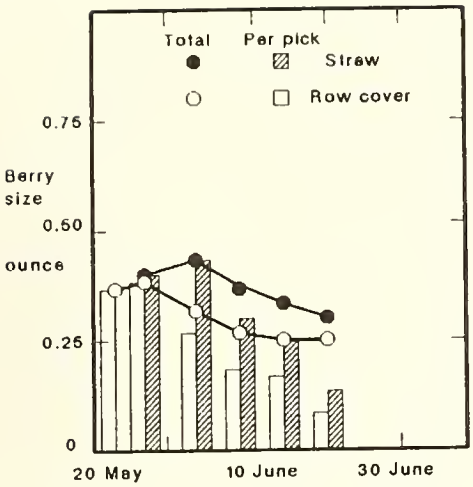

FIGURE 5--BERRY WEIGHT PER PICK (BARS) AND CUMULATIVE WEIGHT PER BERRY SINCE THE START OF PICKING (CURVES) IN 1987 OF EARLIGLOW STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

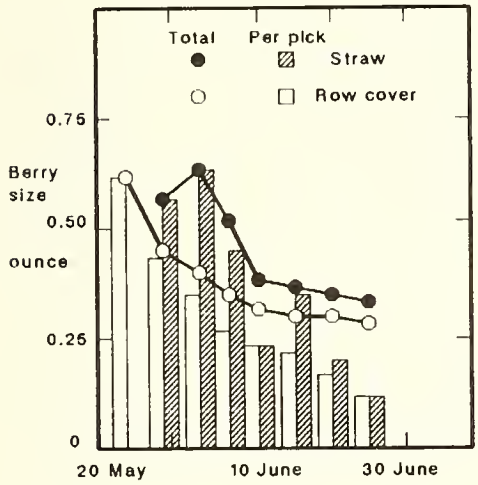

FIGURE 6--BERRY WEIGHT PER PICK (BARS) AND CUMULATIVE WEIGHT PER BERRY SINCE THE START OF PICKING (CURVES) IN 1988 OF EARLIGLOW STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

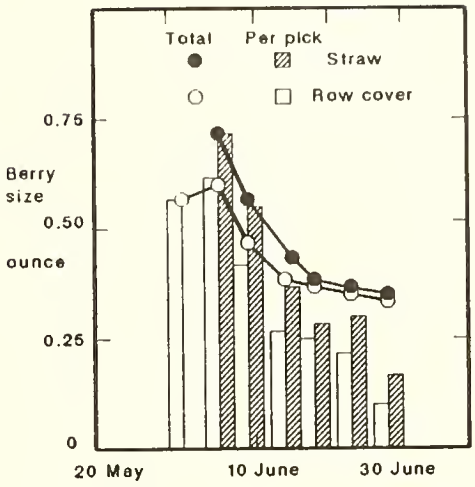

FIGURE 7--BERRY WEIGHT PER PICK (BARS) AND CUMULATIVE BERRY WEIGHT SINCE THE START OF PICKING (CURVES) IN 1987 OF JERSEYBELLE STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

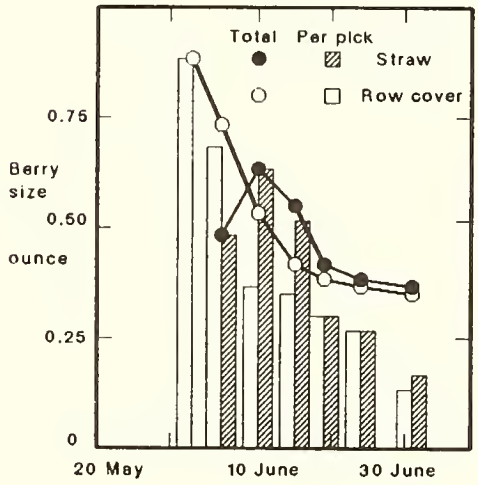

FIGURE 8--BERRY WEIGHT PER PICK (BARS) AND CUMULATIVE BERRY WEIGHT SINCE THE START OF PICKING(CURVES) IN 1988 OF JERSEYBELLE STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

TABLE 8--FRUIT SIZE IN 1987 OF STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
	Berries/pound	
Earlidawn	38.3	46.5
Earliglow	37.8	42.6
Guardian	29.7	40.9
Jerseybelle	31.7	27.4
Midway	39.1	45.9
Redchief	39.4	43.1
Scott	34.1	40.5
Tribute	48.7	55.3
L.S.D. 5%	8.5	
All	36.5	41.8
L.S.D. 5%	4.1	

TABLE 9--FRUIT SIZE IN 1988 OF STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
	Berries/pound	
Earlidawn	46.5	59.0
Earliglow	31.2	38.8
Guardian	32.4	32.6
Jerseybelle	29.3	29.9
Midway	39.5	46.9
Redchief	38.3	49.2
Scott	43.4	45.0
Tribute	47.2	60.4
L.S.D. 5%	6.9	
All	36.3	42.7
L.S.D. 5%	2.3	

TABLE 10--MARKETABLE YIELD AS A PERCENTAGE OF TOTAL YIELD IN 1987 FOR STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
Earlidawn	0.89	0.84
Earliglow	0.91	0.83
Guardian	0.90	0.82
Jerseybelle	0.84	0.83
Midway	0.83	0.81
Redchief	0.86	0.84
Scott	0.84	0.83
Tribute	0.75	0.72
L.S.D. 5%	0.11	
All	0.85	0.81
L.S.D. 5%	0.03	

TABLE 11--MARKETABLE YIELD AS A PERCENTAGE OF TOTAL YIELD IN 1988 FOR STRAWBERRY OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH OR UNDER ROW COVER REMOVED IN EARLY MAY.

Cultivar	Straw	Row Cover
Earlidawn	0.74	0.80
Earliglow	0.92	0.90
Guardian	0.91	0.88
Jerseybelle	0.92	0.93
Midway	0.86	0.82
Redchief	0.86	0.83
Scott	0.87	0.86
Tribute	0.83	0.77
L.S.D. 5%	0.07	
All	0.87	0.85
L.S.D. 5%	0.02	

growth under row cover decreased the percentage of fruit that was marketable. The weight percentage of marketable fruit is shown for each cultivar in Tables 10 and 11 for 1987 and 1988, respectively. The number of malformed berries increased due to row cover but this effect was not measured quantitatively. Some berries, particularly Earlidawn, Midway and Tribute in 1988, showed gray waterlogged areas where they touched the black plastic mulch. These cultivars had less vigor, so less of the plastic mulch was covered by leaves, which tended to permit overheating.

Timing of application and removal of cover

The time of application of row cover in the fall had no significant effect on earliness or yield of strawberries in the following year. The time of removal of the row cover did affect both earliness and the marketable yield. Plants under row cover, even if removed in late March before regrowth began in the spring, yielded earlier than the straw covered control. Averaged over all cultivars, the mid-harvest date was 1 day earlier in 1987 and 2 days earlier in 1988. Roughly speaking, for each 2 week interval that the row covers remained on the plants, from late March to mid-May, the mid-harvest date was advanced by 1 day. Thus in 1987, plants covered until mid-May yielded a day earlier than shown in Table 2. In 1988, there was no benefit of this extra 2 weeks of cover beyond that shown in Table 3.

The penalty for prolonging the period of row cover was a decrease in fruit size. The time of removal of row cover determined the effect on fruit size. The longer that plants remained covered in the spring, the more fruit size was reduced. If the cover was removed in late March, fruit size was similar to that of plants overwintered under straw. The decrease in fruit size was most noticeable for plants under row cover until mid-May. Averaged over all cultivars, plants covered until mid-May in 1987 had a fruit size about 8% less than that shown in Table 8. In 1988, the extra 2 weeks of cover reduced fruit size to 20% less than that reported in Table 9.

Row cover increased total yields regardless of when it was removed in the spring. The percentage of fruit that was marketable decreased the longer the plants remained under row cover. Consequently, the greatest marketable yields were obtained for plants overwintered under row cover that was removed in late March. When row cover remained over the plants until mid-May in 1988, marketable yields of plants grown under row cover were 20% less than yield of plants grown under straw.

DISCUSSION

In this yield trial in Connecticut, strawberries were grown successfully without straw. Plants grown on black plastic mulch and covered with spun bonded polypropylene over the winter months survived as well as those covered with straw. Yields for plants overwintered under row cover removed in early May were higher than yields for those overwintered under straw removed in late March. Flowering and fruit ripening was advanced by use of row cover. The advance in mid-harvest date was largely determined by the date on which row covers were removed in the spring. Although ripening was up to 8 days earlier when the plants remained covered past full bloom, fruit size and marketable yields were reduced. Therefore, a compromise must be made between earliness and fruit size.

The cultivars varied by about 9 days in the time of ripening when grown with straw as a winter mulch. By using row cover in combination with a selection of early and late cultivars, the spread in the picking season could be increased by about 16 days. As an example, Figures 9 and 10 illustrate the amount of fruit picked per week from a plot consisting of equal areas of the early cultivar, Earliglow, grown until early May under row cover, and the late cultivar, Jerseybelle, overwintered under straw. The harvest duration of this combination was five or six weeks, considerably longer than that for either cultivar or cultural practice alone (compare with Figures 1 through 4). The duration of harvest over all cultivars and treatments was

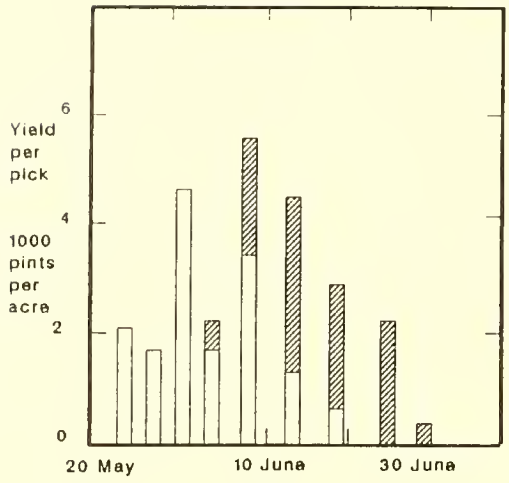

FIGURE 9--YIELD PER PICK IN 1987 OF A PLOT CONSISTING OF EQUAL AREAS OF STRAWBERRY CULTIVARS EARLIGLOW OVERWINTERED UNDER ROW COVER REMOVED IN EARLY MAY (EMPTY PORTION OF EACH BAR) AND JERSEYBELLE OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH (SHADED PORTION OF EACH BAR).

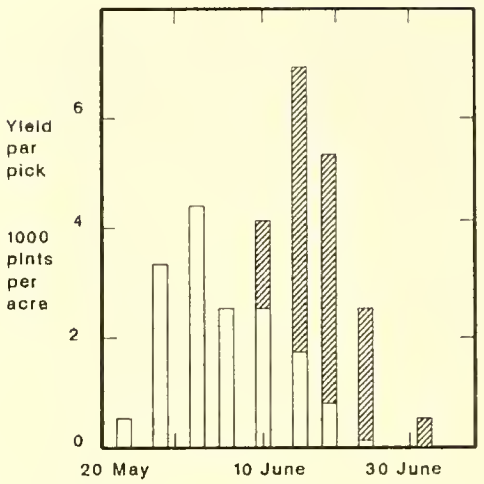

FIGURE 10--YIELD PER PICK IN 1988 OF A PLOT CONSISTING OF EQUAL AREAS OF STRAWBERRY CULTIVARS EARLIGLOW OVERWINTERED UNDER ROW COVER REMOVED IN EARLY MAY (EMPTY PORTION OF EACH BAR) AND JERSEYBELLE OVERWINTERED UNDER STRAW REMOVED IN LATE MARCH (SHADED PORTION OF EACH BAR).

38 days and 40 days, in 1987 and 1988, respectively. Thus, floating row cover used as a winter mulch offers the opportunity to increase the harvest duration of strawberries in Connecticut.

There were some differences in cultivar response to this cultural system compared to conventional cultural methods using straw mulch. Results presented here were compared to those of a yield trial using straw as a winter mulch conducted at the Spring Hill Pomology Farm, Storrs, CT (Shashok and Bible 1988). In general, similar yields were seen for mid-season cultivars under both cultural conditions, except for Midway, which did not survive well on black plastic mulch. However, both the early cultivars, Earlidawn and Earliglow, and the late cultivars, Guardian and Jerseybelle, were more productive in the yield trial with row cover than in the yield trial using straw mulch. In part, these differences could be attributed to location and to the sprinkling for frost protection used in this yield trial but not at Storrs. Part of the difference is likely due to cultivar differences in adaptation to the different cultural conditions.

The fruit quality of cultivars responded differently to the date that row cover was removed. Cultivars such as Midway and Earliglow maintained high marketable yields and good fruit size for all row cover removal dates except for removal on May 16, 1988. For other cultivars, such as Earlidawn and Guardian, marketable yields fell the longer that row cover remained over the plants. Because they maintain good fruit quality, Earliglow and Midway appear to be best suited for early fruit production under row cover.

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